VERTICAL VARIATION IN HEAT FLOW DENSITY IN NORTHERN AREAS - IMPLICATIONS FOR GROUND TEMPERATURES DURING THE LAST GLACIATION

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Detailed analysis of temperatures in boreholes reaching depths of several kilometers often reveals a systematic variation in geothermal gradient and heat flow density with depth. Recent geothermal measurements, regional data compilations and super-deep borehole data suggest considerable vertical variation in the geothermal gradient in NE Fennoscandia, the East European Platform and the Urals. Such data yields evidence on the ground temperatures during the Weichselian glaciation (about 60-10 ka ago). For instance, during the 1990's numerous boreholes were investigated in eastern Karelia and central Kola Peninsula, Russia. After excluding other involved factors potentially contributing to the subsurface thermal regime, such as low crustal radiogenic heat production, or convective heat transfer by groundwater flow, the remaining factor behind the observed vertical temperature gradient variation is often palaeoclimate. The recorded borehole temperatures, anomalously low geothermal gradients and downward increasing gradient in the uppermost 2 km, suggest that very low surface temperatures (-10...-15 deg.C) prevailed on these sites during the glaciation time. The result has interesting implications for the glacier reconstructions: either these areas were free of ice for long times, i.e., periglacial climatic conditions prevailed with permafrost in the ground, or alternatively the glacier was bottom frozen. In contrast to eastern Fennoscandia, geothermal data in Finland and Sweden suggest more normal geothermal gradient values, less vertical variation and thus, higher ground temperatures (about -1 deg.C) during the glaciation, which would suggest basal melting conditions under the glacier. The presence of strong palaeoclimatic disturbances during the Quaternary has been also indicated in deep heat flow data from areas outside the glaciation, such as central Europe, and the Urals. The geothermal evidence, although still sparse and not free of problems, is a very potential source of ground temperature information during the glaciation.